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Final Report for NAGW-1557, entitled

Plasmaspheric Flux Tube Filling via Kinetic Processes

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This document is intended to be the final report for NASA basic research grant NAGW-1557, entitled "Plasmaspheric Flux Tube Filling via Kinetic Processes". The original proposal outlined the initial steps of a project to study the evolution of the kinetic distribution function of plasmaspheric ions f_i driven by Coulomb collisions and other physical processes following a depletion event. The ultimate goal is to develop a theoretical framework and computational procedure based on a bounced-averaged Fokker-Planck equation (described in the original proposal) –

$$\frac{\Delta \hat{f}_i}{\tau_B} = \int_{s_m}^{s_{eq}} \left\{ -\nabla_v \cdot (A_i f_i) + \nabla_v \cdot \nabla_v (D_i f_i) \right\} \frac{ds}{v_{||}}$$

– to allow this problem to be studied, first, in a prototype case with H^+ and O^+ ions emanating from the topside ionosphere and undergoing Coulomb collisions (including self-collisions), with an initial exospheric distribution for the protons, and later, to incorporate additional physical processes (*e.g.* parameterized wave-particle interactions). The original proposal was for 2 years of support, with requested salary support for 6 mm for each year.

The acceptance of the proposal was very encouraging, but only one year of support was granted at a reduced budget, amounting to little more than 3 mm of salary support. This imposed considerable hardship on the P.I., and prevented the P.I. from setting aside a dedicated block of time for the project. Rather, it was necessary to work on the project in a piecemeal manner and only a couple of aspects of the problem could be addressed. Prior to writing the original proposal, considerable progress had been made in formulating the problem, and in fact only a few technical issues remained to be resolved before commencing with the construction of plasmasphere models: namely, the development of computer code for evaluating "bounce-averages" of collision-related quantities along a flux tube at thermal energies (*e.g.* components of the dynamical friction vector A and the diffusion tensor D), the setting up of an efficient interpolation procedure for the kinetic distribution function within each dynamical subcomponent based on the explicitly-calculated points (also needed for the evaluation of the dynamical friction vector A and diffusion tensor D), and the exploration of efficient techniques for the evaluation of certain integrals. The first of these three items has been carried out. There remains, however, a considerable amount of work to be done before prototypical models can be constructed and presented via publication. Eventually a paper will be submitted, but it is not possible to project a completion date. The work is currently being continued, primarily by "stealing time" from other projects (which seems to be the expected mode for the working-out of original ideas by as-yet-unestablished scientists).

Given the very limited support, the P.I. felt (and still feels) considerable pressure to try to salvage something that would be of use to other workers. The P.I. had been approached by Dr. R. A. Wolf of Rice University some time prior to

the awarding of this grant and asked to develop for the magnetospheric modeling group at that institution an algorithm for modeling the evolution of ring current ion densities subject to charge exchange collisions with geocoronal hydrogen atoms. Older kinetic studies of ring current-related problems had, in fact, originally suggested to the P.I. the way to attack the problem of kinetics within the plasmasphere; the two regimes are very similar when viewed from a kinetic standpoint. Consequently, roughly 0.75 mm of support under this grant went to developing a ring current decay algorithm based on the bounce-averaging computer code described above. This algorithm is currently in use at Rice University, and it is anticipated that a brief publication will be submitted at some point within the next year to document it.

Another project that was aided by the funding of this grant was the calculation of baseline kinetic models of the distribution of "hot" geocoronal helium atoms generated by charge exchange collisions between helium atoms of thermospheric origin and plasmaspheric He^+ ions; in these models, the neutral exobase densities were obtained from MSIS and the plasmaspheric helium ion densities calculated using the FLIP model of P. Richards of the University of Alabama. Again, the P.I. undertook this modeling at the request of a scientist (Dr. R. Sheldon, University of Maryland), who needed such models in AMPTE-CCE modeling studies of storm-time ring current evolution. Also, this topic was of interest in that the distribution of "hot" helium atoms might be observable (specifically by the EUV spectrometer on the *Galileo* spacecraft during the terrestrial fly-bys). Approximately 0.5 mm went to supporting this work and a paper has been submitted for publication.

SUBMITTED PAPERS deriving from support under this grant:

"The Extended Helium Geocorona", by J. Bishop, P. Richards, and R. Sheldon, submitted to *J. Geophys. Res.* as a short note

ANTICIPATED PAPERS deriving from support under this grant:

"A Kinetic Formulation for Plasmaspheric Phenomena", by J. Bishop, to be submitted to *Physics of Fluids*

"A Note on the Loss of Ring Current Ions via Geocoronal Charge Exchange", by J. Bishop, R. A. Wolf, and P. G. Richards, to be submitted to *Geophys. Res. Lett.*